

Mineralogical, Elemental and Tomographic Reconnaissance Investigation for CLPS (“METRIC”)

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METRIC comprises a suite of two instruments in a Lunar lander that perform X-ray diffraction (XRD) for mineral structure, X-ray fluorescence (XRF) for elemental composition, and X-ray Micro Computed Tomography (XCT) for 3D internal micromorphology. The instruments are accompanied by optical-near IR cameras to provide local geologic context. The Honeybee Robotics PlanetVac pneumatic sampling and transfer system [1], positioned on a lander footpad, will deliver sieved regolith to the X-ray instruments for analysis. The instrument suite is intended for delivery to the lunar surface on a Commercial Lunar Payload Services (CLPS) lander.

The METRIC XRD/F instrument draws on heritage from the Mars Science Laboratory CheMin instrument [2] and improves upon the design in multiple ways [3]. Like CheMin, Rietveld refinement and full-pattern fitting of METRIC XRD data can identify minerals at a detection limit of ~ 1 wt.%, quantify their abundances when present at ≥ 3 wt.%, and determine mineral composition (e.g., Fo# in olivine) from lattice parameters for minerals present at ≥ 5 wt.% [4,5]. An optimized XRF geometry provides for improved detection and quantification of major, minor and trace elements.

The METRIC XCT instrument is a miniaturized X-ray Computed Tomography scanner [6]. Lunar regolith is delivered to a 3 mm diameter, 10 mm long graphite tube inside the instrument. The tube is rotated through 360° in 0.9 deg. increments and a divergent point source X-ray beam is directed through the material. A Charge Coupled Device (CCD) records attenuation images whose brightness and contrast are a function of average atomic number and density. Quantitative data, including particle and void sizes, 3D particle shape parameters, modal volumes and pore geometry can be derived from the resulting 3D reconstructions (voxel resolution: 30 μm). Crystal morphologies derived from METRIC XCT data complement the bulk mineralogy determined by the METRIC XRD/F and provide a measure of grain size distribution for the different phases.

Taken together, the METRIC instrument suite determines crystal structure, elemental composition and morphology, three principal characteristics of geological materials that are highly useful in determining the origin and subsequent processing of lunar regolith.

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